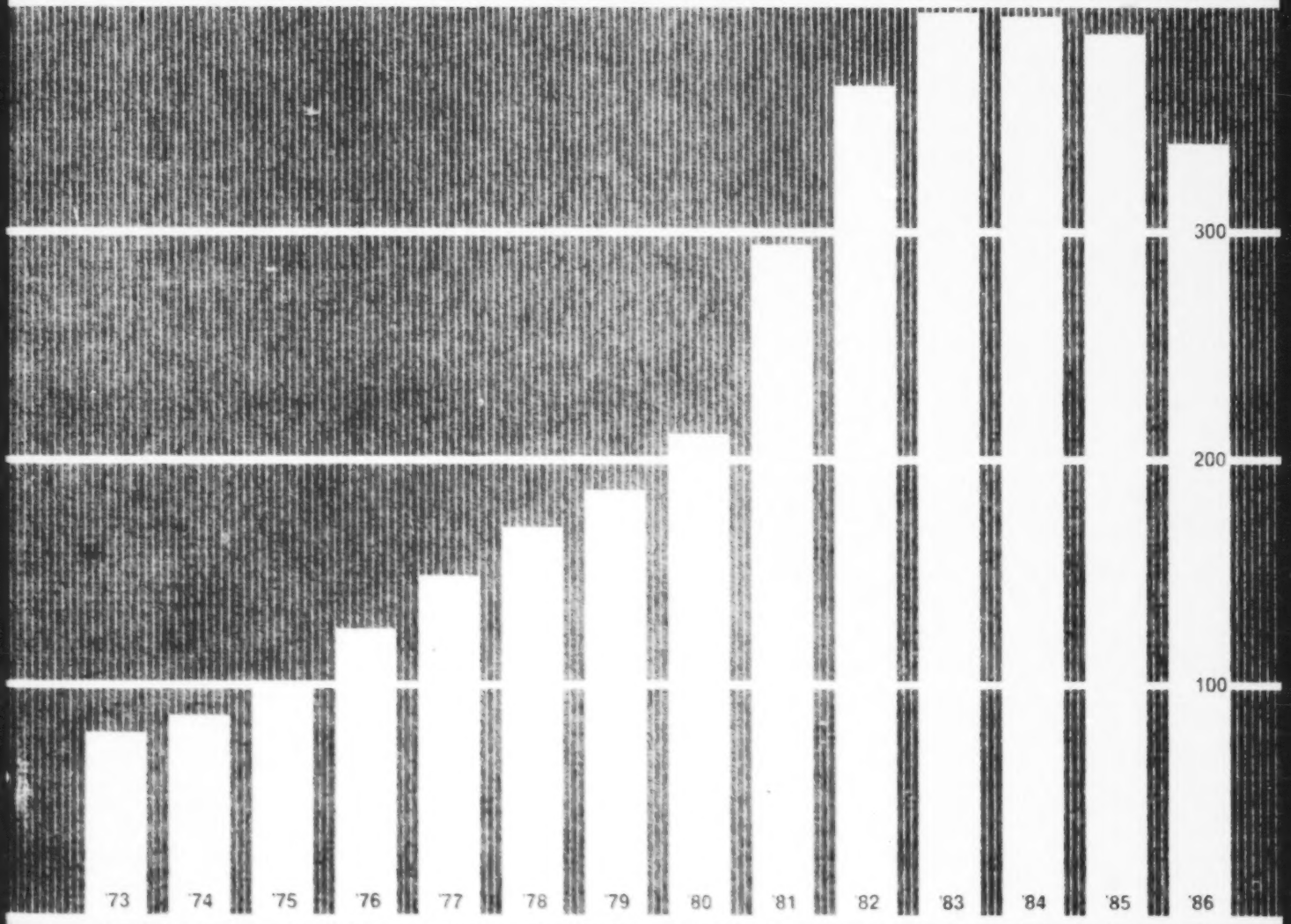
FARM ENERDEMO PROJECT
TASK 1 BACKGROUND REPORT

by

A. Rutherford and M. Gimby



SASKATCHEWAN FARM PETROLEUM PRODUCTS OPERATING EXPENSE (Thousands of Dollars)

SRC Technical
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TABLE OF CONTENTS

Page

LIST OF TABLES ..... (iv)
LIST OF FIGURES ..... (iv)
LIST OF APPENDICES ..... (v)
ACKNOWLEDGEMENTS ..... (vi)
1. INTRODUCTION 1
2. FUEL MONITORING PROGRAM 3
3. TILLAGE PRACTICES AND CROP ROTATION EFFECTS 8
4. ENERGY COST AND INPUT RELATIONSHIPS 11
5. SUMMARY CONCLUSIONS 15
6. REFERENCES 16
APPENDICES 17

LIST OF TABLES

Page

Table 1. Enerdemo Farm Group (1985-86).....3

Table 2. Farm No. 56 General Fuel Use by Unit and Application - April - December, 1986.....4

Table 3. Farm No. 56 Fuel Consumption Rates - Grain-Livestock Enterprise, Dark Brown Soil Zone.....4

Table 4. Average Fuel Consumption Rates - Litres per Acre, Enerdemo Project Farms, 1985 and 1986.....6

Table 5. Selected Examples of Potential Fuel Saving Actions - Enerdemo Project Farms, 1985 and 1986.....6

Table 6. Field Operations Fuel Use by Crop Group - Enerdemo Project Farms, 2 Year Average (1985, 1986).....9

Table 7. Average Fuel, Fertilizer and Herbicide Cost per Acre - Enerdemo Project Farms, 1985 and 1986.....11

Table 8. Average Fuel, Fertilizer and Herbicide Energy Input per Acre - Enerdemo Project Farms, 1985 and 1986.....11

Table 9. Average Fuel, Fertilizer and Herbicide Cost per Acre - Spring Wheat, Enerdemo Project Farms, 1985 and 1986.....12

Table 10. Average Fuel, Fertilizer and Herbicide Energy Input per Acre - Spring Wheat, Enerdemo Project Farms, 1985 and 1986.....12

Table 11. Grain Productivity per Fuel, Fertilizer and Herbicide Cost - Spring Wheat, Enerdemo Project Farms, 1985 and 1986.....13

Table 12. Grain Productivity per Fuel, Fertilizer and Herbicide Energy Input - Spring Wheat, Enerdemo Project Farms, 1985 and 1986.....14

LIST OF FIGURES

Figure 1. Fuels and Lubricants Percent of Farm Operating Expense.....1

Figure 2. Location of Farms Participating In Farm Enerdemo.....2

Figure 3. Field Operations Fuel Use.....8

Figure 4. Relative Energy Cost by Tillage System for Spring Wheat Production (Enerdemo project farms, 1986).....13

LIST OF APPENDICES

Page

Appendix 1. Average Fuel, Fertilizer and Herbicide Consumption per Acre - Enerdemo Project Farms, 1985 and 1985 17

Appendix 1a. Average Fuel, Fertilizer and Herbicide Consumption per Acre by Soil Zone Location - Enerdemo Project Farms, 1985 and 1986 18

Appendix 1b. Average Fuel, Fertilizer and Herbicide Consumption per Acre by Tillage System - Enerdemo Project Farms, 1985 and 1986 19

Appendix 2. Average Fuel, Fertilizer and Herbicide Cost per Acre - Enerdemo Project Farms, 1985 and 1986 20

Appendix 2a. Average Fuel, Fertilizer and Herbicide Cost per Acre by Soil Zone Location - Enerdemo Project Farms, 1985 and 1986 21

Appendix 2b. Average Fuel, Fertilizer and Herbicide Cost per Acre by Tillage System - Enerdemo Project Farms, 1985 and 1986 22

Appendix 3. Average Fuel, Fertilizer and Herbicide Energy Input per Acre - Enerdemo Project Farms, 1985 and 1986 23

Appendix 3a. Average Fuel, Fertilizer and Herbicide Energy Input by Soil Zone Location - Enerdemo Project Farms, 1985 and 1986 24

Appendix 3b. Average Fuel, Fertilizer and Herbicide Energy Input per Acre by Tillage System - Enerdemo Project Farms, 1985 and 1986 25

Appendix 4. Average Wheat (Hard Spring, Durum, HY320) Production per Unit of Energy Consumed and Related Cost - Enerdemo Project Farms, 1985 and 1986 26

Appendix 5. Average Winter Wheat Production per Unit of Energy Consumed and Related Cost - Enerdemo Project Farms, 1985 and 1986 27

Appendix 6. Average Barley Production per Unit of Energy Consumed and Related Cost - Enerdemo Project Farms, 1985 and 1986 28

Appendix 7. Average Oat Production per Unit of Energy Consumed and Related Cost - Enerdemo Project Farms, 1985 and 1986 29

Appendix 8. Average Canola Production per Unit of Energy Consumed and Related Cost - Enerdemo Project Farms, 1985 and 1986 30

Appendix 9. Average Flax Production per Unit of Energy Consumed and Related Cost - Enerdemo Project Farms, 1985 and 1986 31

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1. INTRODUCTION

Unsettled world oil markets have had a significant impact on farm production costs. Since the early 1970's, major petroleum based inputs of fuel, fertilizers and herbicides on Saskatchewan farms, have risen by some 800,000 dollars from about 22 to 34 percent of annual operating expense (Agricultural Statistics 1970-86). The dramatic increase emphasizes the need for effective energy management at the farm level. Under the present situation of depressed grain prices, prairie farmers have little choice in their efforts to maintain an economic operation. From this perspective, both the former *Farm Energy Management Program* (Coxworth *et al*, 1984a, 1984b) and the *Farm Enerdemo Project* (1985-87), reported herein, were undertaken to assess the potential for energy conservation and/or improved efficiency of production practices.

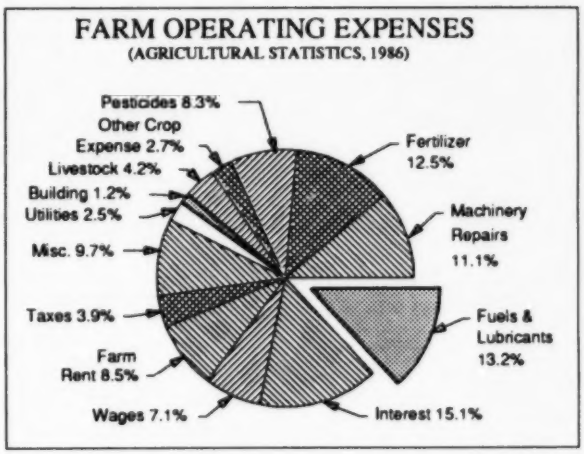

Figure 1. Fuels and lubricants percent of Farm Operating Expense.

FARM OPERATING EXPENSES (Agricultural Statistics, 1986)			
	1977	1981	1986
		$ Million	
Taxes	45.4	69.1	106.8
Farm Rent	109.2	236.5	235.9
Wages	67.8	124.0	195.9
Interest	141.3	448.7	416.9
Fuels & Lubricants	150.3	296.2	366.3
Machinery Repairs	170.1	272.0	306.1
Fertilizer	61.6	198.9	346.6
Pesticides	57.5	131.2	230.9
Other Crop Expenses	26.0	47.3	73.8
Livestock Expenses	57.2	135.7	116.9
Building Repairs	27.1	38.2	34.4
Utilities	33.7	43.7	68.2
Misc. Expenses	119.0	200.0	269.3
Total Operating Exp.	1066.2	2241.5	2768.0
Total Operating & Depreciation Expenses	1449.0	2909.4	3442.3
GOSS INCOME	2238.5	4484.0	4830.0
NET INCOME	789.5	1574.6	1387.7

In contrast to the broad energy review of the FEMP study, the Farm Enerdemo Project was directed to developing a better understanding of farm fuel use. Project efforts, over the 2 year demonstration program, were coordinated around three objectives:

- the evaluation of on-farm fuel monitoring as a cost control technique,
- the determination of fuel requirements of common field operations and their combination in definable cropping systems, and
- the establishment of fuel cost importance relative to other energy costs of cropping practices.

Volunteer farms provided daily fuel measurements and crop production information for a variety of energy comparisons. The following sections present a general outline of procedures together with the results of the investigation.

Figure 2. Location of farms participating in Farm Enerdemo.

2. FUEL MONITORING PROGRAM

Fuel accounting is a relatively new concept introduced in the previous FEMP energy review. Monitoring fuel was recognized as having advantages beyond the allocation of fuel use to farm sectors, in offering the potential to identify lower consumption opportunities. Earlier experience revealed considerable farm cooperator interest in maintaining day to day records, hence, the procedure was expanded in the project with a more suitable logging technique for the analysis of crop production. Fuel recording books, adapted from the demonstration project, are now available from Saskatchewan Agriculture District Offices.

Monitoring was initiated on 44 farms in 1985, with an additional 10 added in 1986 (Saskatchewan 48, Manitoba 3, Alberta 3). The farms, representative of conventional, minimum and zero tillage approaches to crop production, were located among the three major soil zones as illustrated by Figure 2. Their general characteristics are shown in Table 1. Each farm was supplied with two to six fuel meters for installation on stationary and mobile supply tanks. Both mechanical (Fillrite, series 807A) and electronic (Great Plains Industries Inc., model EDM 300) meters were used in the project. Selection of the meters was based solely on their low purchase cost and adaptability to either gravity flow or in line pump operation. Along with the fuel meters, the farms were also supplied with a central or individual unit recording system for tracking fuel consumed by each powered machine and vehicle. Participants were requested to record the quantity of gasoline or diesel fuel used since the last filling, the operation, speed, hours and area covered for power equipment and the portion of fuel usage by heavy trucks and light vehicles relevant to cropping operations. Monitoring on a partial or whole farm basis was optional. However, cooperators were asked for a complete seasonal fuel measurement on one or more fields to assess the accuracy of simulated totals derived from their unit operation averages. Many farms found this inconvenient and opted for a whole farm audit procedure.

Tables 2 and 3 illustrate the type of information produced by routine monitoring. Quality

Table 1.
ENERDEMO FARM GROUP (1985-86)

Feature/Soil Zone	Number of Farms			
	Brown	Dark Brown	Blacks	Total
Farm Size (cult. acres)				
<640	1	-	3	4
640-1600	5	10	9	24
>1600	4	8	9	21
Cropping Rotation				
Continuous	1	5	10	16
Fallow rotation	9	13	11	33
Fallow Practice				
Tillage only	7	8	9	24
Chemicals only	-	3[a]	1[a]	4
Till/Chemicals	2[b]	2[b]	1[b]	5
Seeding System				
Conventional (pre-till)	3	9	17	29
Minimum	5	8	-	13
Zerotill	2	1	4	7
Harvest System				
Swath/Combine	7	13	16	36
Straight Combine	2	2	1	5
Both Methods	1	3	4	8

[a] Minor test acreage

[b] Mainly single fall or early spring season broadleaf application.

Table 2.
Farm No. 56 GENERAL FUEL USE by UNIT and APPLICATION - April-December 1986

Power/Vehicle Unit	Diesel (litres)				Gasoline (litres)			
	Crops	Livestock	Other	Total	Crops	Livestock	Other	Total
1. Bulk purchases								
JD 4440	7516	713	115	8344				
JD 3020	888	276	100	1264				
GMC 3T (100%)*					1611	240		1851
GMC 1/2T (90%)*					1152	381	128	1661
VW Rabbit (25%)*	323		969	1292				
Supplied to:								
Custom Op.	571	381						
Others							40	40
	9258	1370	1184	11852	2763	621	168	3552
2. Off-farm purchases								
GMC 1/2T					53	233	74	360
VW Rabbit			58	58				
	-	-	58	58	53	233	74	360
	9258	1370	1242	11910	2816	854	242	3912
3. Reconciliation	Metered Total		12040		Metered Total		4295	
	Log Record		11910		Log Record		3912	
	Unaccounted		130	litres	Unaccounted		383	litres

* Percentage estimate of farm business use.

Table 3.
Farm No. 56 FUEL CONSUMPTION RATES - Grain-Livestock Enterprise Dark Brown Soil Zone

Field/Farmstead Operation	Machine Unit	Fuel Type	No. Obs.	Litres per Hour Average	Litres per Acre (d.f.e) Range	Litres per Acre (d.f.e) Average
Cultivators						
(primary tillage)	JD 4440	D	12	28.6	1.83 - 2.71	2.23
(secondary tillage)	JD 4440	D	5	20.7	1.36 - 2.09	1.77
Fertilizer banding	JD 4440	D	4	28.7	2.29 - 2.85	2.47
Press drill (d.d.)	JD 4440	D	9	15.7	1.17 - 1.63	1.39
Harrows	JD 4440	D	13	20.0	0.50 - 0.77	0.62
	JD 3020	D	4	10.5	0.27 - 0.53	0.41
Sprayer	JD 3020	D	1	6.2	-	0.21
Chemical applicator	JD 4440	D	2	10.8	0.36 - 0.50	0.43
Mixmill	JD 4440	D	6	17.0	-	-
Baler	JD 3020	D	1	7.1	-	-
Swather (pull)	JD 3020	D	12	7.1	0.60 - 1.09	0.82
Combine (pull)	JD 4440	D	7	18.0	3.14 - 6.15	4.12
Heavy Truck (grain and misc. hauling per seeded acre)	GMC 3T	G		7.0 mpg		2.45
Light Vehicles (general support)	GMC 1/2T VW Rabbit	G D		21.8 mpg 41.4 mpg		3.34

Obs - observations, D - diesel, G - gasoline,
d.f.e. - diesel fuel equivalent (1 litre gasoline = 0.897 litres diesel),
1 mpg = 282.5 litre/100 km

records enable fuel consumption to be separated by machine and end use as shown for the 960 acres (389 ha) mixed farm No. 56, over the 1986 cropping season. Likewise, entries solely related to a specific field operation provided the fuel consumption averages in Table 3. Unrealistic values, inconsistent with the size of equipment, were excluded from the hourly and acreage averages. More general fuel use for vehicles and minor field operations not easily assigned to a definite area are given in terms of overall seeded acreage or as an hourly rate only. Vehicle consumption represents the pooled quantity for all units in the classification group (also includes some minor fuel use of miscellaneous equipment common to the farmstead application, e.g. grain augers, water pumps, etc.). For most farms, difficulties in proportioning fuel from the log records, prompted the use of cooperator estimates of each vehicle's seasonal fuel total applicable to cropping as a means to arrive at an aggregate amount. Marketing deliveries were also excluded from heavy truck estimates to achieve a more uniform farm area value among the project farms. Where a mix of gasoline and diesel units were involved, gasoline quantities were converted to diesel fuel equivalents prior to the summation (1 litre of gasoline = 0.897 litres of diesel fuel based on standard energy content values). Hourly and mileage fuel rates in the tabulations are quoted in terms of actual fuel type, whereas acreage rates are given as diesel fuel equivalents (d.f.e.). The adjustment allows for an easier comparison to other farms. Individual farm summaries are documented in the supplementary report entitled *Farm Fuel Requirements, Enerdemo Project Results.*

An all farm overview of fuel requirements for common field operations and transportation support is presented in Table 4. Included are the number of machine units and fuel record observations used to determine each listed average. Routine monitoring by the *last tank* method, inherently integrates the effects of individual farm variables (road travel, topography, preferred tillage depth, efficiencies of machines and work habits); consequently a range of values are observed. However, on average, with the exception of harvesting operations, little variation can be attributed to soil zone location. Fuels consumed in the transportation support of cropping operations appears to be in the order of 4 litres (d.f.e.) per seeded acre (ca. 10 litres/ha).

Specific *per operation* fuel use, developed from the project fuel logs, in general confirmed expected monitoring benefits. Fuel saving options were apparent in the rudimentary analysis of many farms, particularly where alternative equipment was available. Identified opportunities tended to group into three categories:

- selecting the most fuel efficient tractor or vehicle for the farmstead task,
- modifying operating habits such as wider use of gear up-throttle down, minimum tillage overlap, expedient work patterns and travel planning, and
- reducing the number of field operations through single pass equipment combinations or more extensive changes in cropping practices.

These actions have been widely publicized over the past decade of rising petroleum costs but in many cases not particularly quantified for adjustment decisions (Zoerb, 1983; Erickson, 1984, 1985; and others). Table 5 highlights a few fuel saving examples drawn from the extensive observations recorded by the Enerdemo farm group. Potential fuel savings range up to 1.5 litres per acre (ca. 3.7 litres/ha) for various field operations and, averaged for the group close to 0.2 litres per mile (ca. 12.4 litres/100 km) for efficient light truck selection. While these figures appear negligible on an acreage or mileage basis, over the course of a farm season, the difference noted in consumption translate into an appreciable amount of fuel. At present fuel prices, where these options are feasible to adopt, annual operating costs could be reduced by a few hundred to over a thousand dollars. Transportation, previously shown to account for about 40 percent of farm fuel purchases (FEMP, 1980-83), is the area where the largest savings occur by optimum vehicle use (e.g. $1080 for Farm No. 28 example at 10,000 miles per year). The project evidence indicated that most farms should seriously review their transportation sector.

The cited examples imply that a modest investment in fuel metering for routine or periodic monitoring can have an early pay-back in lower fuel expense. Undoubtedly, a more detailed approach, unique to each farm, would have uncovered other fuel saving possibilities. A survey

Table 4.
AVERAGE FUEL CONSUMPTION RATES - Litres per Acre (d.f.e)* - Enerdemo Project Farms, 1985 and 1986

Field/Farmstead Operation	Units /Obs.	Soil Zone			All Farms
		Brown	Dark Brown	Blacks	
Cultivators (primary till)	64/427	2.04	1.96	2.01	2.00 ± 0.37
(secondary tillage)	35/108	1.84	1.49	1.63	1.62 ± 0.33
Discs (Tandem, offset)	14/38	3.57	1.83	2.52	2.60 ± 1.20
Rodweeders	32/114	1.05	1.14	1.34	1.18 ± 0.52
Discers (seeding)	24/110	1.97	1.63	2.54	1.93 ± 0.39
Press drills (disc)	16/108	1.11	1.18	1.06	1.11 ± 0.18
Hoedrills	14/58	1.69	1.47	1.65	1.61 ± 0.40
Seedrite	5/28	-	2.10	2.38	2.32 ± 0.36
Airseeders	15/99	3.00	1.87	2.11	2.05 ± 0.43
Zero-till drills (disc)	7/41	1.38	1.58	1.45	1.44 ± 0.08
(hoe)	6/32	2.15	2.34	2.24	2.24 ± 0.08
Harrows	56/218	0.76	0.60	0.54	0.60 ± 0.18
Harrow-Packers	18/74	0.98	0.76	0.87	0.87 ± 0.23
Fertilizer banding	40/165	2.30	2.28	2.25	2.27 ± 0.59
Fertilizer broadcast	12/17	0.90	0.74	0.56	0.73 ± 0.49
Chemical Applicators	4/6	-	0.91	0.66	0.78 ± 0.37
Sprayers	53/213	0.35	0.39	0.39	0.38 ± 0.16
Rockpickers (seeded acreage)	19/23	-	-	-	0.26 ± 0.12
Swathers (S.P.)	21/98	0.89	1.09	1.01	1.00 ± 0.43
(pull)	50/182	0.76	0.78	0.79	0.78 ± 0.24
Combines (S.P.-pickup)	30/177	2.18	2.64	3.38	2.85 ± 1.00
(S.P.-straightcut)	18/69	2.46	2.53	2.90	2.64 ± 0.98
(pull-pickup)	29/213	2.81	2.76	2.99	2.85 ± 0.86
Heavy Trucks (per seeded acreage) - grain and misc. hauling other than market deliveries					1.24 ± 0.62
Light Vehicles (per seeded acreage) - general crop production support					2.38 ± 1.16

* d.f.e. - diesel fuel equivalent, for gasoline units multiply by 1.12.

Table 5.
SELECTED EXAMPLES of POTENTIAL FUEL SAVING ACTIONS - Enerdemo Project Farms, 1985 and 1986

Possible Action	Farm No.	Operation	Variance (litres per acre or mile)	Fuel Saving per 1000 acres or miles	
				litres	dollars*
Tractor selection	6	Cultivating - primary tillage	0.80	800	278
		Fertilizer banding	0.61	610	212
Gear up-throttle down operating	9	Discer seeding - same tractor	0.47	470	163
	18	Harrow packer - high Hp tractor contrasted to lower Hp tractor	0.39	390	135
Alternative equipment	9	Swathing - self propelled versus pull type unit	0.40	400	139
	32	Combining - straight cut versus swathing	1.47	1470	510
Vehicle seleIction	40	Heavy trucks - grain and misc. hauling	0.40	400	149
	28	Light trucks - general support of cropping operations	0.29	290	108

* Savings based on gasoline @ 37.3c/l, diesel fuel @ 34.7c/l.

of the cooperators at the close of the program revealed an increased awareness of consumption patterns and attention to fuel conservation. Over 2/3 of the farms reported changes have been made in their farming practices. Selection of fuel efficient units for the job, gear up-throttle down operating, reduction in tillage, and the combination of field operations, along with better planning of trips and farm activities, were among the most popular actions taken. In general, the cooperators recognized benefits derived from fuel monitoring as largely proportional to the attention given to the program. The majority credited the project as a worthwhile effort.

3. TILLAGE PRACTICES AND CROP ROTATION EFFECTS

Approximately a billion litres of gasoline and diesel fuel are consumed in business activities each year by Saskatchewan farms (Farm Energy Use Survey, 1981). A major part of this annual fuel consumption is for crop production. Individual farms vary in usage according to tillage and crop rotation practices. Information on cropping systems collected from the Enerdemo Farms provided a means to establish benchmark fuel requirements. For this purpose, tillage systems are defined by extent of soil disturbance that occurs in the planting year.

Conventional Tillage represents unrestricted operations involving fall and/or spring season preseeding cultivation.

Minimum Tillage refers to a single pass seeding operation only which results in complete soil disturbance, commonly discer or air seeder equipment.

Zero Tillage denotes only seed row soil disturbance, usually in conjunction with a desiccant herbicide application.

To accommodate these definitions, allowance was made for separate fertilizer banding, harrow-packing and straw spreading operations in the latter two tillage systems. Fuel use for each reported crop situation was determined from a listing of field operations and their respective consumption rates. Soil zone averages were used as a default value for farms deficient in a given fuel rate observation. Comparison of such estimates to actual seasonal fuel measurements, taken in the project on selected fields or a whole farm review, indicated an accuracy within 10 percent.

Most Enerdemo farms, by reason of their equipment compliment, tended to follow similar tillage practices for all crops, with the exception of oilseeds (canola, flax) where additional cultivations and press drill seeding was preferred (i.e. conventional tillage classification). Usually only one or two of the defined tillage systems were employed on a given farm. Summerfallowing was predominately by tillage; however, a few farms in the drier soil zones substituted a single broadleaf herbicide treatment to delay cultivating operations. No farms reported extensive use of chemical fallow, hence a meaningful number for fallow crops under this situation was unavailable from the data. In general, the observations conformed to expected crop selection and rotation position among the soil zones.

Fuel requirements by crop group are shown in Table 6 and Figure 3, presented both as all farm

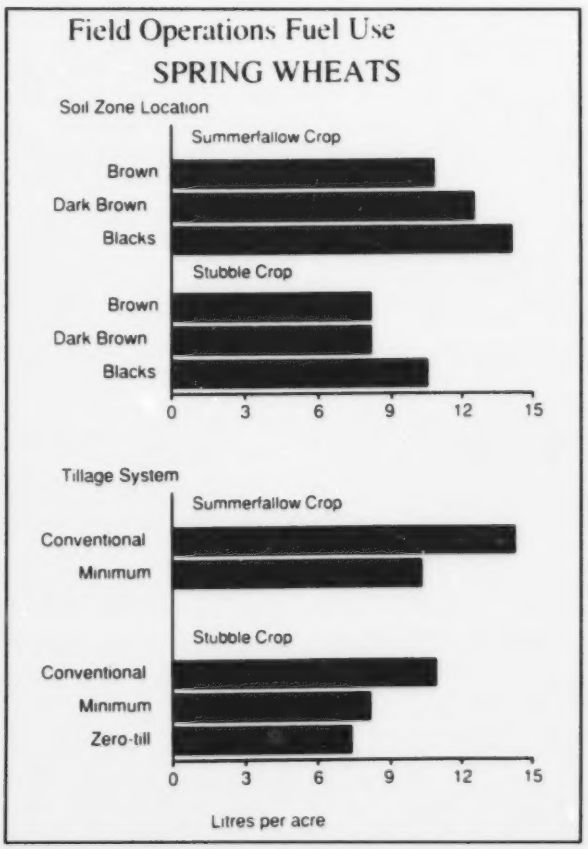

Figure 3. Field operations fuel use.

Table 6.
FIELD OPERATIONS FUEL USE by CROP GROUP -
Enerdemo Project Farms, 2 year Average (1985, 1986)

All Farm Overview

Crop Group	Summerfallow Crop			Stubble Crop		
	Farms	Obs.	Litres/Acre	Farms	Obs.	Litres/Acre
Spring Wheats	27	147	12.2	41	231	9.0
Winter Wheat				19	59	5.6
Coarse Grains	11	13	10.1	29	108	10.4
Oilseeds	14	29	17.9	18	86	11.0

Soil Zone Location

Crop Group	Summerfallow Crop			Stubble Crop		
	Brown	Dark Brown	Blacks	Brown	Dark Brown	Blacks
	(litres per acre)			(litres per acre)		
Spring Wheats	10.8	12.5	14.0	8.2	8.2	10.5
Winter Wheat				4.7	5.3	6.8
Coarse Grains	10.0	9.8	12.3		9.1	11.0
Oilseeds	10.5	14.0	19.6		8.4	11.6

Tillage System

Crop Group	Summerfallow Crop			Stubble Crop		
	Conventional	Minimum	Zero-till	Conventional	Minimum	Zero-till
	(litres per acre)			(litres per acre)		
Spring Wheats	14.3	10.4	n.a.	10.9	8.2	7.4
Winter Wheat						5.6
Coarse Grains	10.9	9.3	n.a.	11.2	7.4	8.0
Oilseeds	19.3	11.1	n.a.	12.7	n.a.	8.1

* number of field observations analysed on reporting farms.
n.a. not available from data.

averages and separated by soil zone location and tillage system. The semi-empirical estimates cover the post harvest to end of harvest period for each crop rotation position. Spring wheats refer to hard varieties and, to a lesser extent durum and HY320; coarse grains to barley and oats; oilseeds to canola and flax. The results predominately represent hard spring wheat, winter wheat, barley and canola. Specific crop input quantities of fuels (d.f.e.), fertilizer products, and active ingredient amount of herbicides are given in appendices 1, 1a and 1b. Cereal crops on summerfallow, over the 2 year production period, require 10 to 14 litres per acre, compared to an 8 to 11 litre per acre range for stubble crops in one year. The corresponding comparison for oilseeds is wider in range because of the noted conventional tillage preference. Winter wheat, viable on stubble by adaptations of zero tillage practices, consumes the lease fuel, at about 6 litres per acre. At minimum, stubble cropping requires 3 to 4 litres less fuel per acre due to the residual effect of fuel consumed in summerfallowing. Better fuel efficiency, in terms of kilograms of grain per litre, occurs if stubble crop yields can exceed two thirds of summerfallow production (i.e. more than the fuel consumption ratio of the rotation positions). A simple shift to more continuous cropping without altering tillage practice, will not in general reduce annual fuel costs. Continuous cropping alone only offers the potential to lower the unit cost of fuels (i.e. less litres per tonne of grain). The soil zone trend of increased fuel usage reflects additional consumption for tillage and harvest operations in the more favorable moisture zones. Proportionately higher crop yields are required for similar fuel efficiencies.

Lowest fuel use correlates with fewer field operations of minimum and zero till systems (Table 6). Both are similar in number of operations and fuel requirements. The project estimates indicate a fuel saving of 3 to 4 litres per acre over conventional tillage, regardless of crop rotation position. On a 1000 cropped acres, annual fuel costs are reduced by 1000 to 1400 dollars. However, these fuel efficient systems, of optimum advantage for recropping on stubble, tend to incur additional fertilizer and/or herbicide expense. The apparent benefit is limited in covering the cost of any herbicide substitute for mechanical tillage (i.e. $1.00-$1.40 per acre). In contrast to a minimum till approach, zero tillage is particularly disadvantaged because of high chemical expense. Lower fuel cost systems need to be enhanced by other economic factors such as a reduction in capital assets and depreciation, labor requirements and soil conservation concerns.

Overall fuel consumption, including transportation support of cropping activities, range from 10 to 18 litres (d.f.e.) per seeded acre. Mid to lower range requirements are associated with stubble cropping by either conventional or reduced tillage methods. The Enerdemo group as a whole average 15.4 litres (d.f.e.) per seeded acre. This figure conforms to earlier FEMP observations of 15.8 (1982) and 17.0 (1983) litres per cultivated acre but somewhat lower than a rough approximation of 20.4 litres per acre (930,180,000 litres d.f.e. -: 45,579,404 acres) derived from the national fuel use survey (FEUS, 1982). Both this study and the previous FEMP data, by independent procedures, corroborate transportation support at about 4 litres per acre. Field operations fuel use shown (Table 6) is considerably less than theoretical projections in the range of 16.5 to 34.6 litres per seeded acre for rotation and soil zone effects (Russell and Colwell, 1981) and estimates of 21.7 to 39.9 litres per acre for cereal production in the northern US states (Pimentel, 1980). While the figures quoted by this project may slightly underestimate field fuel use due to the optimum selection of unit operation rates, the fuel requirements are considered more representative of actual on-farm consumption for present cropping practices.

4. ENERGY COST AND INPUT RELATIONSHIPS

The broad energetics of prairie grain production involves both the direct energy of liquid fuels for motive power and the indirect energy content via manufacture of capital items (depreciation, repair) and crop yield enhancement commodities of fertilizers and herbicides. Previous investigations have shown that the variable components of fuel, fertilizers and herbicides account for 60 to 86 percent of annual energy requirements, the proportion principally influenced by the length of crop rotation (Rutherford and Coxworth, 1986). Of interest to the Enerdemo project was the interrelation of these commodities among the defined tillage systems.

Table 7 presents the 2 year average energy cost for all farms by crop group. For comparison reasons, pricing was based on non-discount

Table 7.
AVERAGE FUEL, FERTILIZER and HERBICIDE COST per ACRE - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs	Fuels	Fert.	Herb.	Total
		Dollars per Acre					Dollars per Acre			
Spring Wheats	27/147	4.73	6.96	7.83	19.52	41/231	3.47	20.25	10.57	34.29
		(24.2)	(35.7)	(40.1)			(10.1)	(59.1)	(30.8)	
Winter Wheat						19/59	2.30	19.04	4.75	26.09
							(8.8)	(73.0)	(18.2)	
Coarse Grains	11/13	3.95	8.63	6.39	18.97	29/108	4.02	19.63	8.97	32.62
		(20.8)	(45.5)	(33.7)			(12.3)	(60.2)	(27.5)	
Oilseeds	14/29	6.91	9.26	13.37	29.54	18/86	4.86	24.59	19.99	49.44
		(23.4)	(31.3)	(45.3)			(9.8)	(49.8)	(40.4)	

() = % of total cost for each energy input.

Table 8.
AVERAGE FUEL, FERTILIZER and HERBICIDE ENERGY INPUT per ACRE - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs	Fuels	Fert.	Herb.	Total
		megajoules per acre					megajoules per acre			
Spring Wheats	27/147	469	327	94	890	41/231	353	1589	89	2031
		(52.7)	(36.7)	(10.6)			(17.4)	(78.2)	(4.4)	
Winter Wheat						19/59	228	1342	39	1609
							(14.2)	(83.4)	(2.4)	
Coarse Grains	11/13	403	389	88	880	29/108	400	1538	99	2037
		(45.8)	(44.2)	(10.0)			(19.6)	(75.5)	(4.9)	
Oilseeds	14/29	690	462	156	1308	18/86	409	1915	129	2453
		(52.8)	(35.3)	(11.9)			(16.7)	(78.1)	(5.2)	

() = % of total energy input.

Table 9.
AVERAGE FUEL, FERTILIZER and HERBICIDE COST per ACRE - Spring Wheat, Enerdemo Project Farms, 1985 and 1986

Tillage System	Soil Zone	Summerfallow Crop Farms /Obs.	Fuels	Fert.	Herb.	Total	Stubble Crop Farms /Obs.	Fuels	Fert.	Herb.	Total
			Dollars per Acre					Dollars per Acre			
Conventional	Brown	5/24	4.96	7.64	7.44	20.04	1/1	2.76	22.93	10.57	36.26
	Dk. Brown	12/36	5.81	5.22	6.52	17.55	14/48	3.95	17.10	5.28	26.33
	Blacks	6/11	5.36	8.61	6.06	20.03	18/55	4.65	21.45	10.44	36.54
		23/71	5.60	6.39	6.84	18.83	33/104	4.27	19.42	7.94	31.63
Minimum	Brown	8/29	3.85	7.42	8.98	20.25	8/16	2.92	14.96	8.46	26.34
	Dk. Brown	12/37	4.04	7.69	8.68	20.41	16/63	2.80	18.34	8.03	29.17
	Blacks	0/0	-	-	-	-	1/11	3.42	26.20	0.69	30.31
		20/66	3.95	7.51	8.65	20.11	25/90	2.84	17.44	7.83	28.11
Zero-till	Brown	0/0					0/0	-	-	-	-
	Dk. Brown	0/0					2/6	1.80	22.89	26.15	50.84
	Blacks	0/0					7/14	3.11	28.44	27.09	58.64
		0/0	-	-	-	-	9/20	2.87	27.36	27.89	58.12
All systems	**All zones**	**46/137**	**4.79**	**7.03**	**7.74**	**19.56**	**67/214**	**3.50**	**19.97**	**10.65**	**34.12**

* Input commodity costs based onn on-discount quotations by Saskatoon area suppliers.

Table 10.
AVERAGE FUEL, FERTILIZER and HERBICIDE ENERGY INPUT per ACRE - Spring Wheat, Enerdemo Project Farms, 1985 and 1986

Tillage Systems	Soil Zone	Summerfallow Crop Farms /Obs.	Fuels	Fert.	Herb.	Total	Stubble Crop Farms /Obs.	Fuels	Fert.	Herb.	Total
			megajoules per Acre					megajoules per Acre			
Conventional	Brown	5/24	501	329	88	918	1/1	307	1942	99	2348
	Dk. Brown	12/36	576	241	86	903	14/48	393	1379	60	1832
	Blacks	6/11	541	627	112	1280	18/55	475	1747	90	2312
		23/71	559	351	91	1001	33/104	460	1557	68	2085
Minimum	Brown	8/29	384	283	104	771	8/16	287	1247	83	1617
	Dk. Brown	12/37	404	330	92	826	16/63	282	1472	86	1840
	Blacks	0/0	-	-	-	-	1/11	305	2037	10	2352
		20/66	394	304	96	794	25/90	283	1367	81	1731
Zero-till	Brown	0/0					0/0	-	-	-	-
	Dk. Brown	0/0					2/6	179	1730	182	2091
	Blacks	0/0					7/14	311	2025	154	2490
		0/0	-	-	-	-	9/20	286	2975	159	2420
All systems	**All zones**	**46/137**	**480**	**339**	**93**	**912**	**67/214**	**354**	**1575**	**89**	**2018**

quotations by Saskatoon area suppliers. Actual costs varied among the farms but are essentially the same as those reported in a comprehensive treatment of grain production expense conducted for 1986 by the University of Saskatchewan, Agriculture Economics Department (Schoney, 1987). Not unexpected, summerfallow crops show the least energy cost, at about $20 per acre for cereals and $30 per acre for oilseeds (ca. $50 and $74 per hectare). The higher oilseed expense reflects a predominate Black soil zone production location (i.e. fuel usage) and a somewhat greater attention to grassy weed control (i.e. higher cost wild oat - green foxtail herbicides). In contrast, stubble crops are more energy intensive because of additional nitrogen

Table 11.
GRAIN PRODUCTIVITY per FUEL, FERTILIZER and HERBICIDE COST - Spring Wheat, Enerdemo Project Farms, 1985 and 1986

Tillage System	Soil Zone	Summerfallow Crop Grain Kilograms per Energy Costs ($)				Stubble Crop Grain Kilograms per Energy Cost ($)			
		Actual (1985)	Expected* (1985)	Actual (1986)	Expected* (1986)	Actual (1985)	Expected* (1985)	Actual (1986)	Expected* (1986)
Conventional	Brown	18.4	30.2	79.5	64.3	n.a.	n.a.	33.3	20.5
	Dk. Brown	37.0	46.0	75.7	61.3	12.7	18.3	38.3	25.3
	Blacks	59.5	69.0	33.3	36.0	24.6	17.8	28.9	24.3
		33.4	44.6	55.7	47.4	16.0	18.1	33.0	24.1
Minimum	Brown	23.6	34.3	68.2	56.3	9.7	16.7	35.5	27.0
	Dk. Brown	33.2	41.5	47.8	38.1	19.7	20.5	30.6	21.9
	Blacks	n.a.	n.a.	n.a.	n.a.	26.7	23.2	n.a.	n.a.
		28.8	38.5	58.0	47.2	16.6	19.5	32.1	23.5
Zero-till	Brown					n.a.	n.a.	n.a.	n.a.
	Dk. Brown					9.8	10.5	7.3	7.8
	Blacks					21.7	14.0	19.3	10.6
		n.a.	n.a.	n.a.	n.a.	18.1	13.3	15.9	9.8
Allsystems	Brown	22.0	33.2	73.2	59.9	9.7	16.7	34.6	24.1
	Dk. Brown	33.8	43.4	53.1	41.1	15.5	18.7	31.6	22.0
	Blacks	59.5	69.0	33.3	36.0	23.5	16.3	26.1	20.3
		30.6	40.9	57.4	47.3	16.6	17.6	27.4	21.8

* Long term yield average from Saskatchewan Crop Insurance Tables.
n.a. - no data available from farm group.

fertilizer and, in some cases, herbicide applications (e.g. zero till systems) considered necessary by the farm cooperators for acceptable crop yields. Energy costs are approximately 1.7 times higher, at $34 per acre for cereals and $50 per acre for oilseed production. There is a notable inverse relationship between direct fuel and indirect energy inputs with respect to crop rotation position. Fuels account for 20 to 25 percent of the variable energy expense of summerfallow crops but declines to about 10 percent for stubble crops. Non-fuel energy requirements tend to be a more important concern in recropping rotations. Recent government rebate programs have further reduced the importance of fuel expense; nevertheless, effective use lies within farm control.

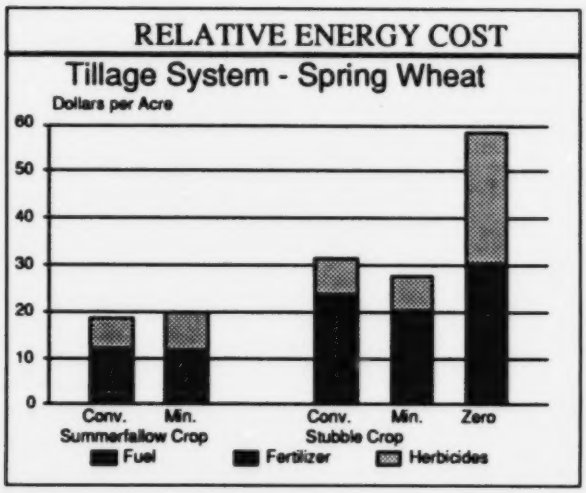

Figure 4. Relative energy cost by tillage system for spring wheat production (Enerdemo Project Farms, 1985 and 1986

Comparison of tillage and soil zone effects on energy cost for spring wheat production is shown in Table 9 and Figure 4. (Other crops show essentially the same pattern). Apart from the expected differences in fuel costs, the impact of herbicide expense in zero till systems is most evident. For the Enerdemo farm group, zero till participants were synonymous with continuous cropping operations and somewhat higher than average in fertilizer use. Corresponding consumption in terms of energy content (megajoules per acre), as determined from literature coefficients (Boerma et al, 1980), is given in Tables 8

Table 12.
GRAIN PRODUCTIVITY per FUEL, FERTILIZER and HERBICIDE ENERGY INPUT
- Spring Wheat, Enerdemo Project Farms, 1985 and 1986

Tillage System	Soil Zone	Summerfallow Crop Grain Kilograms per Energy Input (GJ)				Stubble Crop Grain Kilograms per Energy Input (GJ)			
		Actual (1985)	Expected* (1985)	Actual (1986)	Expected* (1986)	Actual (1985)	Expected* (1985)	Actual (1986)	Expected* (1986)
Conventional	Brown	517	832	1258	1018	n.a.	n.a.	513	296
	Dk. Brown	790	1005	1034	784	224	293	488	382
	Blacks	814	942	702	754	427	298	444	373
		729	961	1003	842	281	296	471	364
Minimum	Brown	680	1000	1414	1178	221	308	540	436
	Dk. Brown	935	1126	1137	891	335	325	459	315
	Blacks	n.a.	n.a.	n.a.	n.a.	344	299	n.a.	n.a.
		820	1074	1275	1034	289	319	484	353
Zero-till	Brown					n.a.	n.a.	n.a.	n.a.
	Dk. Brown					240	256	216	231
	Blacks					478	309	474	335
		n.a.	n.a.	n.a.	n.a.	410	298	400	305
Allsystems	Brown	630	951	1345	1107	221	307	528	374
	Dk. Brown	865	1069	1081	1070	275	333	449	335
	Blacks	814	942	702	754	438	303	453	362
		778	1023	1117	922	308	320	465	327

* Long term yield average from Saskatchewan Crop Insurance Tables.
n.a. - no data available from farm group.

and 10. While notable differences occur between the cost and energy content of the commodities among the average cropping practices, absolute energy use parallels the increased dollar cost of stubble crops. Nitrogen fertilizers, due to their natural gas feedstock, are the dominant factor in the comparison. In general, these energy inputs are largely independent of production outcome.

Tables 11 and 12 show the grain return per dollar of energy investment and energy content consumption respectively. (Available data for crops other than spring wheat are tabulated in appendices 4 through 9). The results are given for each year of the project in terms of actual reported production and expected production based on Crop Insurance yield data. Differences in the expected grain returns arise from variations in costs and reporting farms each year. The observations reflect drought conditions in 1985 for a large part of the Brown and Dark Brown soil zones and more normal yields throughout the zones in 1986. On average over the 2 years, grain return indices appear close to longer term expectations. Lower risk summerfallow crops return about twice the grain per dollar cost and triple the grain per gigajoule[1] of energy input compared to stubble crops. The limited observations indicate approximately 44 kilograms per dollar versus 22 kilograms per dollar (1.6 bushels vs 0.8 bushels per dollar). On the basis of annual energy investment, the zero tillage farms are shown to be the least profitable. The treatment illustrates the low operating margin and high energy demand of continuous cropping. Under inflexible energy costs, grain prices are a critical factor. This is the present dilemma.

1) 10^6 joules = 1 megajoule, 10^3 megajoules = 1 gigajoule.
1 gigajoule = 10^9 joules

5. SUMMARY CONCLUSIONS

The Enerdemo project has demonstrated that on-farm fuel monitoring can be a positive step in the efficient use of gasoline and diesel fuels. Routine application on project farms identified practical fuel saving actions with the potential to reduce annual costs from a few hundred to over a thousand dollars. Most cooperators expressed satisfaction with the performance of low cost meters and the recording logs now adopted for distribution by Saskatchewan Agriculture.

Fuel monitoring results have collectively established reference fuel consumption rates for common field and farmstead operations. Direct seasonal measurement or more convenient summation by field operation rates facilitates the comparison of cropping systems. Project observations indicate aggregate field consumption in the range of 10 to 14 litres per acre for summerfallow crops (2 year production period) and 8 to 11 litres per acre for stubble crops (1 year production period). Variation within a rotation position arises from tillage practice and to a less extent soil zone location. Improved efficiency of fuel use, in terms of grain return per litre, occurs when stubble crop yields are in excess of two thirds of summerfallow production (i.e. aggregate fuel consumption ratio of the rotation positions). Minimum or zero till practices, as defined, reduce the fuel requirement for the production of a given crop by at least 3 to 4 litres per acre, independent of cropping rotation. This fuel saving is only marginal for the trade-off cost of herbicide substitutes for tillage weed control. In this respect, a minimum tillage approach appears the most favorable. Farm area transportation support of cropping activities consumes about 4 litres per seeded acre. Overall fuel consumption can be expected in the range of 10 to 18 litres per cropped acre. The Enerdemo farm group showed an average of 15.4 litres per acre.

Fuel costs are at the lower end of energy expenses incurred in crop production. For summerfallow crops, fuel costs account for about 25 percent but decline to 10 percent for stubble crops. In general, nitrogen fertilizers necessary for recropping and, in particular, herbicides for zero till practices, dominate the variable production expense of continuous cropping systems. Grain productivity, at present costs, contrast by a factor of two, about 44 kilograms and 22 kilograms per energy dollar investment for summerfallow and stubble crops respectively. On the basis of energy content input, stubble crops are about three times more energy intensive. All petroleum-based input commodities need to be efficiently managed for optimum economic production.

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Appendix 1.

AVERAGE FUEL, FERTILIZER and HERBICIDE CONSUMPTION per ACRE - Enerdemo Project Farms, 1985 and 1986

Crop Grown	Summerfallow Crop					StubbleCrop				
	Farms	Obs.	Fuels (L)	Fert. (kg)	Herb. (kgAcI)	Farms	Obs.	Fuels (L)	Fert. (kg)	Herb. (kgAcI)
1985										
All Wheats	19	78	11.2	15.1	0.43	27	103	8.1	60.7	0.36
Hard Spring	17	66	11.4	15.7	0.43	23	81	8.5	61.4	0.38
Durum	4	8	9.3	21.0	0.43	8	19	7.5	62.8	0.35
HY320	4	4	11.7	6.2	0.44	3	3	5.4	48.9	0.29
Winter Wheat	-	-	-	-	-	11	25	5.7	78.8	0.20
Coarse Grains	7	8	10.1	21.1	0.31	18	48	9.5	54.1	0.42
Barley	6	7	9.6	20.2	0.35	15	42	9.8	59.0	0.53
Oats	1	1	13.1	27.7	0.00	6	6	8.8	41.6	0.17
Oilseeds	8	14	16.3	20.7	0.40	13	40	9.8	76.1	0.41
Canola	7	13	17.1	20.8	0.36	9	32	10.3	83.6	0.39
Flax	1	1	10.4	18.1	0.67	6	8	9.2	65.0	0.43
1986										
All Wheats	24	69	13.2	23.2	0.40	48	128	9.8	65.8	0.32
Hard Spring	21	61	13.6	23.9	0.39	38	111	9.9	62.8	0.31
Durum	3	8	11.0	18.2	0.49	9	16	9.1	77.8	0.35
HY320	-	-	-	-	-	1	1	10.1	72.4	0.23
Winter Wheat	-	-	-	-	-	15	34	5.6	47.6	0.20
Coarse Grains	5	5	10.1	23.7	0.35	28	60	11.2	59.8	0.44
Barley	5	5	10.1	23.7	0.35	22	54	11.0	63.2	0.49
Oats	-	-	-	-	-	6	6	11.7	47.5	0.23
Oilseeds	12	15	19.4	32.8	0.50	20	46	12.1	76.6	0.30
Canola	10	12	20.3	33.9	0.51	11	32	13.2	74.3	0.35
Flax	2	3	14.8	27.2	0.48	9	14	10.7	79.3	0.24

L - litres (d.f.e.), kg - kilograms fertilizer products,
KgAcI - Kilograms active ingredients herbicide products

Appendix 1a.

AVERAGE FUEL, FERTILIZER and HERBICIDE CONSUMPTION per ACRE by SOIL ZONE LOCATION -Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms	Obs.	Fuels (L)	Fert. (kg)	Herb. (kgAcI)	Farms	Obs.	Fuels (L)	Fert. (kg)	Herb. (kgAcI)
1985										
Brown Soil Zone										
Spring Wheats	4	22	10.0	19.9	0.47	4	8	7.6	61.6	0.41
Winter Wheat	-	-	-	-	-	3	5	4.1	57.9	0.14
Coarse Grains	1	1	10.9	18.1	0.90	-	-	-	-	-
Oilseeds	1	1	10.5	18.1	0.67	-	-	-	-	-
Dark Brown Soil Zone										
Spring Wheats	13	51	11.6	12.7	0.43	13	57	7.5	53.1	0.27
Winter Wheat	-	-	-	-	-	5	11	6.3	77.4	0.22
Coarse Grains	5	6	9.6	22.1	0.26	8	11	8.0	31.1	0.20
Oilseeds	3	5	15.9	31.5	0.35	3	4	7.8	48.5	0.28
Black Soil Zones										
Spring Wheats	2	5	11.4	17.8	0.29	9	38	9.5	72.9	0.49
Winter Wheat	-	-	-	-	-	3	9	6.1	102.2	0.23
Coarse Grains	1	1	12.1	18.1	0.04	10	37	10.5	68.2	0.56
Oilseeds	4	8	20.0	12.8	0.37	9	36	10.4	83.1	0.44
1986										
Brown Soil Zone										
Spring Wheats	9	38	11.5	18.0	0.41	9	20	8.7	55.4	0.27
Winter Wheat	-	-	-	-	-	3	7	5.2	40.6	0.15
Coarse Grains	2	2	9.1	21.6	0.46	-	-	-	-	-
Oilseeds	-	-	-	-	-	1	2	13.8	60.6	0.11
Dark Brown Soil Zone										
Spring Wheats	11	25	13.4	23.0	0.38	22	65	8.9	62.0	0.35
Winter Wheat	-	-	-	-	-	5	12	7.5	60.3	0.26
Coarse Grains	2	2	10.0	20.4	0.32	6	14	10.1	52.1	0.27
Oilseeds	7	8	20.4	23.8	0.43	3	5	8.9	65.0	0.19
Black Soil Zones										
Spring Wheats	4	6	16.6	35.4	0.44	17	43	11.3	70.4	0.28
Winter Wheat	-	-	-	-	-	5	12	7.5	60.3	0.26
Coarse Grains	1	1	12.4	34.7	0.09	22	46	11.5	61.9	0.48
Oilseeds	9	11	19.1	35.8	0.53	16	39	12.6	79.8	0.33

Appendix 1b.

AVERAGE FUEL, FERTILIZER and HERBICIDE CONSUMPTION per ACRE by TILLAGE SYSTEM - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms	Obs.	Fuels (L)	Fert. (kg)	Herb. (kgAcI)	Farms	Obs.	Fuels (L)	Fert. (kg)	Herb. (kgAcI)
1985										
Conventional Tillage										
Spring Wheats	10	34	13.6	12.2	0.42	12	42	10.4	54.0	0.34
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	3	3	11.0	21.3	0.22	13	39	10.4	46.3	0.35
Oilseeds	6	12	18.2	24.3	0.35	8	30	11.3	59.0	0.33
Minimum Tillage										
Spring Wheats	12	44	9.9	17.3	0.45	13	50	6.6	57.4	0.27
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	5	5	9.5	21.0	0.36	2	4	6.5	30.5	0.35
Oilseeds	2	2	10.3	9.1	0.56	-	-	-	-	-
Zero-Till										
Spring Wheats	-	-	-	-	-	4	11	6.8	85.1	0.67
Winter Wheat	-	-	-	-	-	11	25	5.7	78.8	0.20
Coarse Grains	-	-	-	-	-	3	5	7.2	111.2	0.84
Oilseeds	-	-	-	-	-	4	10	7.6	101.9	0.52
1986										
Conventional Tillage										
Spring Wheats	14	39	15.0	24.2	0.35	25	71	11.5	61.8	0.29
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	3	3	10.8	25.9	0.11	21	50	12.0	54.6	0.26
Oilseeds	11	13	19.8	33.3	0.50	13	36	14.0	88.6	0.39
Minimum Tillage										
Spring Wheats	10	30	10.8	21.8	0.48	16	46	7.9	57.4	0.37
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	2	2	9.0	20.4	0.66	3	6	8.3	45.8	0.26
Oilseeds	1	2	11.8	31.8	0.56	1	2	7.8	39.5	0.11
Zero-Till										
Spring Wheats	-	-	-	-	-	5	11	8.0	99.0	0.57
Winter Wheat	-	-	-	-	-	15	34	5.6	47.6	0.20
Coarse Grains	-	-	-	-	-	4	4	8.7	97.9	1.23
Oilseeds	-	-	-	-	-	5	8	8.6	79.4	0.38

Appendix 2.

AVERAGE FUEL, FERTILIZER and HERBICIDE COST per ACRE - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs.	Fuels	Fert.	Herb.	Total
		(Dollars per Acre)					(Dollars per Acre)			
1985										
All Wheats	19/78	4.87	6.42	8.04	19.33	27/103	3.55	22.10	9.66	35.31
Hard Spring	17/66	4.98	6.61	8.11	19.70	23/81	3.69	22.69	10.52	36.90
Durum	4/8	4.05	9.15	6.99	20.19	8/19	3.28	21.02	7.94	32.24
HY320	4/4	5.12	2.72	8.79	16.63	3/3	3.14	20.04	7.09	30.27
Winter Wheat	-	-	-	-	-	11/25	2.48	25.41	4.65	32.54
Coarse Grains	7/8	4.40	8.82	6.27	19.49	18/48	4.16	20.36	10.89	35.41
Barley	6/7	4.20	8.53	7.17	19.90	15/42	4.29	21.74	12.67	38.70
Oats	1/1	5.69	10.81	0.00	16.50	6/6	3.82	16.92	6.46	27.20
Oilseeds	8/14	7.09	8.14	15.32	30.55	13/40	4.29	26.72	19.91	50.92
Canola	7/13	7.44	8.18	15.31	30.93	9/32	4.48	29.56	19.48	53.52
Flax	1/1	4.60	7.19	15.34	27.13	6/8	4.00	22.45	20.55	47.00
1986										
All Wheats	24/69	4.59	7.50	7.61	19.70	48/128	3.39	18.39	11.47	33.25
Hard Spring	21/61	4.70	7.63	7.44	19.77	38/111	3.44	17.84	11.64	32.92
Durum	3/8	3.82	6.58	8.83	19.23	9/16	3.15	20.78	11.55	35.48
HY320	-	-	-	-	-	1/1	3.51	17.75	4.34	25.60
Winter Wheat	-	-	-	-	-	15/34	2.11	12.67	4.84	19.62
Coarse Grains	5/5	3.50	8.43	6.50	18.43	28/60	3.88	18.89	7.04	29.81
Barley	5/5	3.50	8.43	6.50	18.43	22/54	3.83	19.70	8.38	31.91
Oats	-	-	-	-	-	6/6	4.08	15.93	2.12	22.13
Oilseeds	12/15	6.73	10.37	11.41	28.51	20/46	5.42	22.45	20.07	47.94
Canola	10/12	7.05	10.61	10.92	28.58	11/32	4.58	23.28	17.94	45.80
Flax	2/3	5.14	9.14	13.87	28.15	9/14	6.45	21.43	22.68	50.56

* Input commodity costs based on non-discount quotations by Saskatoon area suppliers.

Appendix 2a.

AVERAGE FUEL, FERTILIZER and HERBICIDE COST per ACRE by SOIL ZONE LOCATION - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs.	Fuels	Fert.	Herb.	Total
		Dollars per Acre					Dollars per Acre			
1985										
Brown Soil Zone										
Spring Wheats	4/22	4.40	8.34	10.83	23.57	4/8	3.34	19.24	10.16	32.74
Winter Wheat	-	-	-	-	-	3/5	1.79	17.82	3.76	23.37
Coarse Grains	1/1	4.75	7.91	17.83	30.49	-	-	-	-	-
Oilseeds	1/1	4.60	7.91	7.91	20.42	-	-	-	-	-
Dark Brown Zone										
Spring Wheats	13/51	5.06	5.52	7.50	18.08	13/57	3.26	19.32	6.35	28.93
Winter Wheat	-	-	-	-	-	5/11	2.76	25.38	6.28	34.42
Coarse Grains	5/6	4.18	9.42	5.09	18.69	8/11	3.50	12.00	6.57	22.07
Oilseeds	3/5	6.93	11.72	13.22	31.87	3/4	3.39	18.23	15.37	36.99
Black Soil Zones										
Spring Wheats	2/5	4.97	6.83	1.74	13.54	9/38	4.12	27.69	15.07	46.88
Winter Wheat	-	-	-	-	-	3/9	2.12	33.04	2.83	37.99
Coarse Grains	1/1	5.28	6.15	1.84	13.27	10/37	4.56	25.50	13.55	43.61
Oilseeds	4/8	7.83	5.52	16.88	30.23	9/36	4.51	28.84	21.04	54.39
1986										
Brown Soil Zone										
Spring Wheats	9/38	4.00	6.18	6.58	16.76	9/20	3.02	13.65	6.38	23.05
Winter Wheat	-	-	-	-	-	3/7	1.79	10.31	8.75	20.85
Coarse Grains	2/2	3.14	7.82	9.49	20.45	-	-	-	-	-
Oilseeds	-	-	-	-	-	1/2	4.79	11.51	2.59	18.89
Dark Brown Soil Zone										
Spring Wheats	11/25	4.66	7.53	7.43	19.62	22/65	3.10	17.77	10.20	31.07
Winter Wheat	-	-	-	-	-	7/15	1.90	11.46	1.48	14.84
Coarse Grains	2/2	3.47	7.56	5.73	16.76	6/14	3.52	17.43	4.87	25.82
Oilseeds	3/4	7.08	8.75	10.21	26.04	3/5	3.08	18.70	12.96	34.74
Black Soil Zones										
Spring Wheats	4/6	5.74	10.38	10.37	26.49	17/43	3.96	21.70	15.81	41.47
Winter Wheat	-	-	-	-	-	5/12	2.59	15.78	7.21	25.58
Coarse Grains	1/1	4.29	11.37	2.06	17.72	22/46	3.98	19.29	7.63	30.90
Oilseeds	9/11	6.62	10.91	11.81	29.34	16/39	5.90	23.83	22.50	52.23

Appendix 2b.

AVERAGE FUEL, FERTILIZER and HERBICIDE COST per ACRE by TILLAGE SYSTEM - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs.	Fuels	Fert.	Herb.	Total
		dollars per acre					dollars per acre			
1985										
Conventional Tillage										
Spring Wheats	10/34	5.97	5.14	6.75	17.86	12/42	4.55	20.67	7.15	32.37
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	3/3	4.77	8.71	4.85	18.33	13/39	4.52	18.21	8.50	31.23
Oilseeds	6/12	7.95	9.54	15.64	33.13	8/30	4.94	21.61	14.52	41.07
Minimum Tillage										
Spring Wheats	12/44	4.04	7.38	9.01	20.43	13/50	2.90	19.73	6.26	28.89
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	5/5	4.16	8.89	7.13	20.18	2/4	2.82	11.72	3.64	18.18
Oilseeds	2/2	4.50	3.96	14.36	22.82	-	-	-	-	-
Zero-Till										
Spring Wheats						4/11	2.97	31.77	22.23	56.97
Winter Wheat						11/25	2.48	25.41	4.65	32.54
Coarse Grains						3/5	3.13	37.59	28.50	69.22
Oilseeds						4/10	3.32	34.38	27.99	65.69
1986										
Conventional Tillage										
Spring Wheats	14/39	5.18	7.43	6.53	19.14	25/71	3.97	18.28	7.24	29.49
Winter Wheat	-	-	-	-	-					
Coarse Grains	3/3	3.76	9.00	2.16	14.92	21/50	4.18	18.06	4.69	26.93
Oilseeds	11/13	7.07	10.25	11.59	28.91	13/36	4.89	23.21	17.40	45.50
Minimum Tillage										
Spring Wheats	10/30	3.76	7.59	9.12	20.47	16/46	2.74	15.57	8.19	26.50
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	2/2	3.11	7.41	13.01	23.53	3/6	2.87	15.33	4.48	22.68
Oilseeds	1/2	4.10	10.41	11.64	26.15	1/2	2.76	14.77	0.84	18.37
Zero-Till										
Spring Wheats						5/11	2.78	25.23	34.12	62.13
Winter Wheat						15/34	2.11	12.67	4.84	19.62
Coarse Grains						4/4	3.04	25.92	21.28	50.24
Oilseeds						5/8	2.98	22.07	29.09	54.14

Appendix 3.

AVERAGE FUEL, FERTILIZER and HERBICIDE ENERGY INPUT per ACRE
- Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs.	Fuels	Fert.	Herb.	Total
		(megajoules per acre)					(megajoules per acre)			
1985										
All Wheats	19/78	432	237	103	772	27/103	315	1615	89	2019
Hard Spring	17/66	442	254	103	799	23/81	327	1699	95	2121
Durum	4/8	359	298	98	755	8/19	291	1485	80	1856
HY320	4/4	454	89	104	647	3/3	279	1262	64	1605
Winter Wheat	-	-	-	-	-	11/25	220	1671	44	1935
Coarse Grains	7/8	390	425	106	921	18/48	369	1415	116	1900
Barley	6/7	373	299	121	793	15/42	381	1473	143	1997
Oats	1/1	505	1308	0	1813	6/6	339	1271	47	1657
Oilseeds	8/14	629	387	141	1157	13/40	381	1983	144	2508
Canola	7/13	661	406	137	1204	9/32	398	2091	152	2641
Flax	1/1	408	258	171	837	6/8	355	1821	133	2309
1986										
All Wheats	24/69	505	417	85	1006	48/128	390	1563	88	2041
Hard Spring	21/61	516	439	83	1038	38/111	399	1534	91	2024
Durum	3/8	425	258	97	780	9/16	352	1684	80	2116
HY320	-	-	-	-	-	1/1	392	1557	37	1986
Winter Wheat	-	-	-	-	-	15/34	235	1013	34	1282
Coarse Grains	5/5	415	352	70	837	28/60	431	1660	82	2173
Barley	5/5	415	352	70	837	22/54	424	1692	91	2207
Oats	-	-	-	-	-	6/6	454	1541	50	2045
Oilseeds	12/15	751	537	170	1458	20/46	437	1846	113	2396
Canola	10/12	786	535	176	1497	11/32	451	1910	105	2466
Flax	2/3	573	550	137	1260	9/14	419	1769	122	2310

Appendix 3a.

AVERAGE FUEL, FERTILIZER and HERBICIDE ENERGY INPUT by SOIL ZONE LOCATION - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs.	Fuels	Fert.	Herb.	Total
		(megajoules per acre)					(megajoules per acre)			
1985										
Brown Soil Zone										
Spring Wheats	4/22	388	300	125	813	4/8	293	1407	105	1805
Winter Wheat	-	-	-	-	-	3/5	159	1196	39	1394
Coarse Grains	1/1	422	258	459	1139	-	-	-	-	-
Oilseeds	1/1	408	258	171	837	-	-	-	-	-
Dark Brown Zone										
Spring Wheats	13/51	430	188	90	708	13/57	289	1415	69	1773
Winter Wheat	-	-	-	-	-	5/11	245	1877	53	2175
Coarse Grains	5/6	371	466	62	899	8/11	311	782	58	1151
Oilseeds	3/5	615	707	129	1451	3/4	301	1552	101	1954
Black Soil Zones										
Spring Wheats	2/5	441	429	119	989	9/38	366	2015	112	2493
Winter Wheat	-	-	-	-	-	3/9	238	1803	34	2075
Coarse Grains	1/1	469	345	18	832	10/37	404	1790	151	2345
Oilseeds	4/8	695	180	180	1055	9/36	401	2091	155	2647
1986										
Brown Soil Zone										
Spring Wheats	9/38	446	284	76	806	9/20	336	1185	68	1589
Winter Wheat	-	-	-	-	-	3/7	200	849	35	1084
Coarse Grains	2/2	350	306	110	766	-	-	-	-	-
Oilseeds	-	-	-	-	-	1/2	534	529	17	1080
Dark Brown Soil Zone										
Spring Wheats	11/25	519	377	92	988	22/65	345	1570	85	2000
Winter Wheat	-	-	-	-	-	7/15	212	867	22	1101
Coarse Grains	2/2	387	290	50	727	6/14	385	1482	56	1923
Oilseeds	3/4	790	552	152	1494	3/5	343	1756	57	2156
Black Soil Zones										
Spring Wheats	4/6	640	824	105	1569	17/43	475	1753	102	2330
Winter Wheat	-	-	-	-	-	5/12	289	1315	50	1654
Coarse Grains	1/1	479	569	28	1076	22/46	443	1708	89	2240
Oilseeds	9/11	738	524	176	1438	16/39	448	1946	142	2536

Appendix 3b.

AVERAGE FUEL, FERTILIZER and HERBICIDE ENERGY INPUT per ACRE by TILLAGE SYSTEM - Enerdemo Project Farms, 1985 and 1986

Crop Group	Summerfallow Crop					Stubble Crop				
	Farms /Obs.	Fuels	Fert.	Herb.	Total	Farms /Obs.	Fuels	Fert.	Herb.	Total
		(megajoules per acre)					(megajoules per acre)			
1985										
Conventional Tillage										
Spring Wheats	10/34	520	202	101	823	12/42	404	1574	85	2063
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	3/3	424	332	55	811	13/39	401	1359	94	1854
Oilseeds	6/12	706	473	132	1311	8/30	438	1667	143	2248
Minimum Tillage										
Spring Wheats	12/44	359	263	104	726	13/50	257	1466	65	1788
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	5/5	369	481	137	987	2/4	250	792	106	1148
Oilseeds	2/2	399	129	169	697	-	-	-	-	-
Zero-Till										
Spring Wheats						4/11	263	2110	163	2536
Winter Wheat						11/25	220	1671	44	1935
Coarse Grains						3/5	278	2134	239	2651
Oilseeds						4/10	295	2731	167	3193
1986										
Conventional Tillage										
Spring Wheats	14/39	584	479	76	1139	25/71	456	1551	64	2071
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	3/3	419	394	21	834	21/50	466	1622	70	2158
Oilseeds	11/13	788	503	170	1462	13/36	545	1866	116	2527
Minimum Tillage										
Spring Wheats	10/30	419	333	97	849	16/46	305	1400	85	1790
Winter Wheat	-	-	-	-	-	-	-	-	-	-
Coarse Grains	2/2	347	290	142	779	3/6	306	1339	42	1687
Oilseeds	1/2	457	696	151	1304	1/2	308	1568	14	1890
Zero-till										
Spring Wheats						5/11	310	1976	168	2454
Winter Wheat						15/34	235	1013	34	1282
Coarse Grains						4/4	338	2097	175	2610
Oilseeds						5/8	332	1850	124	2306

Appendix 4.

AVERAGE WHEAT (Hard Spring, Durum, HY320) PRODUCTION per UNIT of ENERGY CONSUMED AND RELATED COST - Enerdemo Project Farms, 1985 and 1986

Tillage System	Soil Zone	Summerfallow Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected	Stubble Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected
1985											
Conventional	Brown	2/5	517	832	18.4	30.2	0/0	-	-	-	-
	Dk. Brown	6/24	790	1005	37.0	46.0	6/23	224	293	12.7	18.3
	Blacks	2/5	814	942	59.5	69.0	6/19	427	298	24.6	17.8
		10/34	729	961	33.4	44.6	12/42	281	296	16.0	18.1
Minimum	Brown	4/17	680	1000	23.6	34.3	4/8	221	308	9.7	16.7
	Dk. Brown	8/25	935	1126	33.2	41.5	8/31	335	325	19.7	20.5
	Blacks	0/0	-	-	-	-	1/1	344	299	26.7	23.2
		12/42	820	1074	28.8	38.5	13/50	289	319	16.6	19.5
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						1/3	240	256	9.8	10.5
	Blacks						3/8	478	309	21.7	14.0
		0/0	-	-	-	-	4/11	410	298	18.1	13.3
All systems	Brown	4/22	630	951	22.0	33.2	4/8	221	307	9.7	16.7
	Dk. Brown	12/49	865	1069	33.8	43.4	13/57	275	333	15.5	18.7
	Blacks	2/5	814	942	59.5	69.0	9/38	438	303	23.5	16.3
		18/76	778	1023	30.6	40.9	26/103	308	320	16.6	17.6
1986											
Conventional	Brown	4/21	1258	1018	79.5	64.3	4/9	513	296	33.3	20.5
	Dk. Brown	6/12	1034	784	75.7	61.3	9/26	488	382	38.3	25.3
	Blacks	4/6	702	754	33.3	36.0	12/36	444	373	28.9	24.3
		14/39	1003	842	55.7	47.4	25/71	471	364	33.0	24.1
Minimum	Brown	5/19	1414	1178	68.2	56.3	5/11	540	436	35.3	27.0
	Dk. Brown	5/13	1137	891	47.8	38.1	11/35	459	315	30.6	21.9
	Blacks	0/0	-	-	-	-	0/0	-	-	-	-
		10/32	1275	1034	58.0	47.2	16/46	484	353	32.1	23.5
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						2/4	216	231	7.3	7.8
	Blacks						5/7	474	335	19.3	10.6
		0/0	-	-	-	-	7/11	400	305	15.9	9.8
All systems	Brown	9/38	1345	1107	73.2	59.9	9/20	528	374	34.6	24.1
	Dk. Brown	11/25	1081	1070	53.1	41.1	22/65	449	335	31.6	22.0
	Blacks	4/6	702	754	33.3	36.0	17/43	453	362	26.1	20.3
		24/69	1117	922	57.4	47.3	48/128	465	327	27.4	21.8

GJ = gigajoules = 1000 megajoules

Expected Kilograms of grain based on long term yield average from Saskatchewan Crop Insurance Tables.

Appendix 5.

AVERAGE WINTER WHEAT PRODUCTION per UNIT of ENERGY CONSUMED AND RELATED COST - Enerdemo Project Farms, 1985 and 1986.

Tillage System	Soil Zone	Summerfallow Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected	Stubble Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected
1985											
Conventional	Brown										
	Dk. Brown										
	Blacks										
		0/0	-	-	-	-	0/0	-	-	-	-
Minimum	Brown										
	Dk. Brown										
	Blacks										
		0/0	-	-	-	-	0/0	-	-	-	-
Zero-till	Brown						3/6	201	373	12.0	25.3
	Dk. Brown						5/11	199	280	12.5	17.4
	Blacks						3/9	474	355	24.8	18.8
		0/0	-	-	-	-	11/26	237	320	14.3	19.5
Allsystems	Brown						3/6	201	373	12.0	25.3
	Dk. Brown						5/11	199	280	12.5	17.4
	Blacks						3/9	474	355	24.8	18.8
		0/0	-	-	-	-	11/26	237	320	14.3	19.5
1986											
Conventional	Brown										
	Dk. Brown										
	Blacks										
		0/0	-	-	-	-	0/0	-	-	-	-
Minimum	Brown										
	Dk. Brown										
	Blacks										
		0/0	-	-	-	-	0/0	-	-	-	-
Zero-till	Brown						3/7	699	914	30.3	34.0
	Dk. Brown						7/15	618	827	42.8	59.3
	Blacks						5/12	574	2150	37.6	141.7
		0/0	-	-	-	-	15/34	620	1285	38.6	81.7
All systems	Brown						3/7	699	914	30.3	34.0
	Dk. Brown						7/15	618	827	42.8	59.3
	Blacks						5/12	574	2150	37.6	141.7
		0/0	-	-	-	-	15/34	620	1285	38.6	81.7

Appendix 6.

AVERAGE BARLEY PRODUCTION per UNIT of ENERGY CONSUMED and RELATED COST - Enerdemo Project Farms, 1985 and 1986

Tillage System	Soil Zone	Summerfallow Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected	Stubble Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected
1985											
Conventional	Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Dk. Brown	2/2	976	1267	38.4	48.0	3/4	460	462	30.3	27.7
	Blacks	1/1	1440	1326	90.3	83.1	7/29	567	371	34.0	21.7
		3/3	1093	1276	47.5	55.9	10/33	539	394	33.1	23.2
Minimum	Brown	1/1	842	969	31.4	36.2	0/0	-	-	-	-
	Dk. Brown	3/3	1131	1478	51.4	62.7	2/4	508	577	31.8	36.3
	Blacks	0/0	-	-	-	-	0/0	-	-	-	-
		4/4	1042	1307	44.3	53.0	2/4	508	577	31.8	36.3
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						0/0	-	-	-	-
	Blacks						3/5	459	358	17.7	13.7
		0/0	-	-	-	-	3/5	459	358	17.7	13.7
All systems	Brown	1/1	842	969	31.4	36.2	0/0	-	-	-	-
	Dk. Brown	5/5	1063	1379	45.2	55.9	5/8	483	502	31.0	30.6
	Blacks	1/1	1440	1326	90.3	83.1	10/34	529	367	26.6	18.4
		7/7	1063	1293	45.6	54.2	15/42	515	403	27.8	21.2
1986											
Conventional	Brown	1/1	786	1350	43.1	74.1	0/0	-	-	-	-
	Dk. Brown	1/1	2218	1269	113.2	64.7	4/9	681	444	45.8	29.9
	Blacks	1/1	1520	858	92.1	52.0	12/36	657	398	50.5	29.9
		3/3	1508	1159	82.8	63.6	16/45	663	410	49.3	29.9
Minimum	Brown	1/1	1863	1341	55.4	39.9	0/0	-	-	-	-
	Dk. Brown	1/1	1668	1428	63.8	54.6	2/5	603	344	50.5	28.1
	Blacks	0/0	-	-	-	-	1/1	564	544	36.2	34.9
		2/2	1765	1385	59.6	47.2	3/6	590	411	45.9	30.4
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						0/0	-	-	-	-
	Blacks						3/3	516	359	24.9	17.4
		0/0	-	-	-	-	3/3	516	359	24.9	17.4
All systems	Brown	2/2	1326	1345	49.3	57.0	0/0	-	-	-	-
	Dk. Brown	2/2	1944	1350	88.5	59.6	6/14	455	411	47.4	29.3
	Blacks	1/1	1520	858	92.1	52.0	16/40	625	401	44.8	27.9
		5/5	1611	1250	73.5	57.0	22/54	577	403	45.5	28.3

Appendix 7.

AVERAGE OAT PRODUCTION per UNIT of ENERGY CONSUMED and RELATED COST - Enerdemo Project Farms, 1985 and 1986.

Tillage System	Soil Zone	Summerfallow Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected	Stubble Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected
1985											
Conventional	Brown						0/0	-	-	-	-
	Dk. Brown						3/3	472	556	18.0	22.5
	Blacks						3/3	470	276	35.7	21.0
		0/0	-	-	-	-	6/6	471	369	23.9	21.7
Minimum	Brown	0/0									
	Dk. Brown	1/1	298	416	32.7	45.8					
	Blacks	0/0	-	-	-	-					
		1/1	298	416	32.7	45.8	0/0	-	-	-	-
Zero-till	Brown										
	Dk. Brown										
	Blacks										
		0/0	-	-	-	-	0/0	-	-	-	-
All systems	Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Dk. Brown	1/1	298	416	32.7	45.8	3/3	472	556	18.0	22.5
	Blacks	0/0	-	-	-	-	3/3	470	276	35.7	21.0
		1/1	298	416	32.7	45.8	6/6	471	369	23.9	21.7
1986											
Conventional	Brown						0/0	-	-	-	-
	Dk. Brown						0/0	-	-	-	-
	Blacks						5/5	552	316	53.8	31.0
		0/0	-	-	-	-	5/5	552	316	53.8	31.0
Minimum	Brown										
	Dk. Brown										
	Blacks										
		0/0	-	-	-	-	0/0	-	-	-	-
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						0/0	-	-	-	-
	Blacks						1/1	369	333	31.1	28.2
		0/0	-	-	-	-	1/1	369	333	31.1	28.2
All systems	Brown						0/0	-	-	-	-
	Dk. Brown						0/0	-	-	-	-
	Blacks						6/6	521	319	50.1	30.5
		0/0	-	-	-	-	6/6	521	319	50.1	30.5

Appendix 8.

AVERAGE CANOLA PRODUCTION per UNIT of ENERGY CONSUMED and RELATED COST - Enerdemo Project Farms, 1985 and 1986

Tillage System	Soil Zone	Summerfallow Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected	Stubble Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected
1985											
Conventional	Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Dk. Brown	3/5	143	269	6.6	12.3	0/0	-	-	-	-
	Blacks	3/7	599	466	20.5	13.6	6/25	209	159	10.5	8.0
		6/12	230	341	10.0	12.9	6/25	209	159	10.5	8.0
Minimum	Brown	0/0	-	-	-	-					
	Dk. Brown	0/0	-	-	-	-					
	Blacks	1/1	816	773	25.5	24.2					
		1/1	816	773	25.5	24.2	0/0	-	-	-	-
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						0/0	-	-	-	-
	Blacks						3/7	237	138	10.6	6.3
		0/0	-	-	-	-	3/7	237	138	10.6	6.3
All systems	Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Dk. Brown	3/5	143	269	6.6	12.3	0/0	-	-	-	-
	Blacks	4/8	642	517	21.5	15.3	9/32	217	152	10.6	7.4
		7/13	257	371	10.9	13.8	9/32	217	152	10.6	7.4
1986											
Conventional	Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Dk. Brown	3/4	458	386	26.4	22.3	1/2	175	127	10.7	7.8
	Blacks	7/8	558	358	27.0	17.0	8/28	327	191	14.5	8.7
		10/12	528	367	26.8	18.6	9/30	310	183	14.1	8.6
Minimum	Brown										
	Dk. Brown										
	Blacks										
		0/0	-	-	-	-	0/0	-	-	-	-
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						0/0	-	-	-	-
	Blacks						2/2	367	168	14.5	7.0
		0/0					2/2	367	168	14.5	7.0
All systems	Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Dk. Brown	3/4	458	386	26.4	22.3	1/2	175	127	10.7	7.8
	Blacks	7/8	558	358	27.0	17.0	10/30	336	186	14.5	8.4
		10/12	528	367	26.8	18.6	11/32	322	181	14.1	8.3

Appendix 9.

AVERAGE FLAX PRODUCTION per UNIT of ENERGY CONSUMED and RELATED COST - Enerdemo Project Farms, 1985 and 1986.

Tillage System	Soil Zone	Summerfallow Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected	Stubble Crop Farms /Obs.	Grain (Kg/GJ) Actual	Grain (Kg/GJ) Expected	Grain (Kg/$) Actual	Grain (Kg/$) Expected
1985											
Conventional	Brown						0/0	-	-	-	-
	Dk. Brown						2/3	116	166	8.5	12.3
	Blacks						1/2	317	181	15.8	11.0
		0/0	-	-	-	-	3/5	147	171	10.0	11.9
Minimum	Brown	1/1	425	588	12.8	17.7					
	Dk. Brown	0/0	-	-	-	-					
	Blacks	0/0	-	-	-	-					
		1/1	425	588	12.8	17.7	0/0	-	-	-	-
Zero-till	Brown						0/0	-	-	-	-
	Dk. Brown						1/1	86	145	3.0	5.0
	Blacks						2/2	229	154	10.4	7.0
		0/0	-	-	-	-	3/3	147	151	5.7	6.2
All systems	Brown	1/1	425	588	12.8	17.7	0/0	-	-	-	-
	Dk. Brown	0/0	-	-	-	-	3/4	104	158	5.2	8.3
	Blacks	0/0	-	-	-	-	3/4	252	162	11.8	8.0
		1/1	425	588	12.8	17.7	6/8	147	160	7.3	8.1
1986											
Conventional	Brown	0/0	-	-	-	-	1/2	165	222	9.4	12.9
	Dk. Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Blacks	1/1	434	432	15.8	15.7	3/4	241	180	12.1	9.2
		1/1	434	432	15.8	15.7	4/6	222	192	11.4	10.2
Minimum	Brown	0/0	-	-	-	-	0/0	-	-	-	-
	Dk. Brown	0/0	-	-	-	-	1/2	269	165	27.7	17.1
	Blacks	1/2	615	343	30.6	17.1	0/0	-	-	-	-
		1/2	615	343	30.6	17.1	1/2	269	165	27.7	17.1
Zero-till	Brown	0/0					0/0	-	-	-	-
	Dk. Brown						1/1	143	142	6.6	6.6
	Blacks						3/5	633	340	13.4	7.2
		0/0	-	-	-	-	4/6	511	291	11.7	7.1
All systems	Brown	0/0	-	-	-	-	1/2	165	222	9.4	12.9
	Dk. Brown	0/0	-	-	-	-	2/3	206	154	16.8	11.9
	Blacks	2/3	554	373	23.2	16.4	6/9	437	260	12.7	8.2
		2/3	554	373	23.2	16.4	9/14	356	233	13.4	9.6